Introduction of Native Species Diversity into Exotic Lovegrass Infestations

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Introduction

Much of Southern Arizona's diverse grasslands are increasingly threatened by the invasion of exotic lovegrasses, but little is known about their management or control, or the economic return from such efforts. In fall 2005, the Tucson PMC harvested seed from the abundant grasslands of the Audubon Societies' Appleton-Whittell Research Ranch in Elgin, Arizona. Using seed from that harvest, two replicated studies were initiated in 2006 on the Ranch to investigate the potential for patch establishment of native species into invasive-dominated sites of lehmann lovegrass (*Eragrostis lehmanianna*) and Boer lovegrass (*E. curvula*). Both of these species have been present in small quantities on the Ranch for years, but have become dominant over much of the range following the catastrophic Ryan fire in 2002.

Methods

Seed harvested from the ranch was minimally processed (once through the hammermill) for use in both projects. Multiple species of grasses and forb seed, including *Eragrostis intermedia, Bouteloua gracilis, B. hirsuta, B. eriopoda, B. curtipendula, B. chondrosioides, Bothriochloa barbinodis, Digitaria californica, Lycurus phleoides, Leptochloa dubia, Aristida spp., Sida filicaulis, Ipomoea coccinea, Viguiera annua, Convolvulus equitans* were identified in the seed mix. The harvest site was selected based on its low density of exotic grasses. Because the few Lehmann lovegrass patches at the site were avoided while harvesting, very little Lehmann lovegrass should have entered the mix.

Project 1: Lehmann lovegrass

One project was conducted in collaboration with both the University of Arizona and the research ranch to test different patch sizes for native species establishment in Lehmann lovegrass-dominated stands by herbicide and seeding. At four similar sites: three replications of three plot sizes, $1m^2$, $2m^2$ and $4m^2$ patches, were randomly placed within a 50 m area. In July the 24 plots were mowed with a weed eater, and 7 days later sprayed with 5% application of Glyphosate (Roundup). Following spraying, equal proportions of seed were spread evenly across all plots and raked in. The recommended range seeding rate of 20 seed/square ft (approx. 0.02 g seed/square ft) was doubled to increase the opportunity for germination.

PMC intern, Megan Otto, rakes in seed following spraying

Linda Kennedy (Audubon Society), Jeff Fehmi and Jason Stevens (University of Arizona) painstakingly examine each seedling in the $1m^2$

Following the summer rains, every seedling observed in the plots were Lehmann lovegrass, the same exotic grass surrounding the plots. No native seedlings were observed in any of the plots. This project was unsuccessful because no conclusions could be drawn about small patch establishment of native species. The native grass seed broadcasted either disappeared (possibly consumed by granivores) or did not germinate in the plots. No data were analyzed for this study.

PMC interns Jace Householder and Megan Otto seed the plots.

Project 2: Boer lovegrass

In a second project the PMC collaborated with the Research Ranch to reduce the dominance of Boer lovegrass and increase native diversity with the use of several cultural practices:

Mowing- with diesel tractor and rotary mower
Broad-spectrum herbicide- Roundup Ultra 5% rate and blue dye
Growth suppressant- Embark 2-S at 4 pints/ac and blue dye
Seeding- Native seed planted with FLXII Truax No-Till Grass Drill (4-5" depth)

Four replications of the following treatments were equal in size and arranged randomly in replicated complete block grid pattern (Figure 1):

- mow & herbicide & seed
- mow & growth suppressant & seed
- mow & seed
- seed only
- control

All 20 plots were 50 ft by 8 ft, with a 5 ft buffer around each plot to prevent overlap of treatments. The equipment was passed through each block to ensure uniformity of the treatments. Plots were delineated by colored rebar stakes.

Plot pattern following mowing and spraying

The plots were set up and treated during the month of July. Four of the five treatments (16 plots) were mowed. Seven days later, four of the mowed plots were sprayed with herbicide, and another four of those plots were sprayed with a growth suppressant hormone. Three days following the spraying, four of the five treatments (all but the control plots) were

seeded with a drill. Approximately 40 seed/sq ft were seeded in the plots, double the recommended range seeding rate to increase the opportunity of germination. Approximately 14.46 lb/ac was used in each of the drill's boxes (fluffy seed and small seed) for all plots combined. The growth suppressant hormone treatment was not effective due to multiple rainfall events. The treatment would have needed to be reapplied and was not, so this treatment was dropped from the study.

Seedlings began to emerge following the summer rains July through September, and on October 19 the four active treatments in the Boer treatments were evaluated. Data were collected from within a 1 m x 0.5 m frame placed randomly twice in each plot. Seedlings were identified within and between the drill rows in each frame. The four treatments were evaluated according to the following variables:

- Mean frequency of native grass seedlings
- Mean frequency of mature native grasses
- Mean frequency of exotic grass seedlings
- Mean frequency of mature exotic grasses
- Mean frequency of perennial forb seedlings
- Mean frequency of mature perennial Forbs
- Mean species composition of seedlings
- Mean species composition of mature plants
- Vegetation cover in frame (using Daubbenmeier score)

Jennifer Arnold (NRCS Tucson Field Office), Linda Kennedy and PMC intern Leslie Wood and examine seedlings in the frame.

Frequencies of individual plants in the plots previous to treatment (mature native grasses, Forbs and exotic grasses) were recorded separately in each frame. Frequencies of native grass, forb and exotic grass seedlings were also counted in each frame using a seedling identification guide. Species composition was listed for mature plants and seedlings; these totals number represent the species composition variable. Cover was estimated in each frame using Daubbenmeier scores.

Results

The plots that were sprayed with herbicide had significantly lower cover scores than the plots that were not sprayed ($p=0.0053$). There was no difference in mean frequency of mature native grasses ($p=0.147$), exotic grasses ($p=0.203$) or mature Forbs ($p=0.75$) between treatments.

Species composition of mature plants in the plots was significantly lower in the sprayed plots ($p<0.0005$).

Table 1. Cover, Mature Grasses and Plant Composition following Treatment

Treatment	N	Vegetation Cover (%)	Species composition of mature plants (#)
Mow & Herbicide & Seed	8	11.63 b	0.25 b
Mow & Seed	8	45.25 a	6.28 a
Seed only	8	42.50 a	4.25 a
Control	8	53.13 a	5.38 a

Values followed by the same letter are not significantly different ($\alpha=0.05$)
Randomized complete block AOV and LSD All-Pairwise Tukey Test were conducted.

A significantly greater number of native grass seedlings established in the sprayed plots than the control plots ($p=0.023$). Neither treatment differed significantly from those that were mowed and seeded or seeded only. A greater number of exotic grass seedlings established in the sprayed plots than the mowed plots, although this difference was not statistically significant ($p=0.084$). Of the 32 total plots examined, 3 plots had Boer lovegrass seedlings, and 8 plots had Lehmann lovegrass seedlings. Three of the eight plots containing Lehmann lovegrass seedlings were in the plots sprayed with herbicide. Numbers of forb seedlings did not differ between treatments.

Seedlings emerging from drill rows in a plot mowed, sprayed and seeded.

Species composition of seedlings was significantly greater in the sprayed plots than the other treatments ($p=0.0003$).

Table 2. Frequency and Composition of Seedlings Following Treatment

Treatment	N	Native grass seedlings (#)	Exotic grass seedlings (#)	Species composition of seedlings (#)
Mow & Herbicide & Seed	8	70.72 a	18.28	8.13 a
Mow & Seed	8	43.00 ab	0.75	4.35 b
Seed only	8	45.50 ab	5.38	2.75 b
Control	8	11.00 ab	5.88	2.87 b

Values follwed by the same letter are not significantly different ($\alpha=0.05$)
Randomized complete block AOV and LSD All-Pairwise Tukey Test were conducted.

Discussion

The project that drilled seed into the soil (Boer lovegrass) rather than broadcast and raked into the soil (Lehmann lovegrass) allowed for differences to be demonstrated between treatments. The largest plots (4m x 4m) in the Lehmann lovegrass stands may have not been large enough to show an effect. Vulnerability to seed predators and wind is greater in smaller plots. In the Boer lovegrass study, the plots were not only larger but the seed drilled into the soil provided better protection from granivores and other sources of seed removal.

The Boer lovegrass study demonstrated several interesting findings, all of which were related to herbicide application. Herbicide use following mowing and seeding increased vegetation cover, produced the greatest native and exotic grass seedling increase, and the greatest seedling species composition.

These effects point in favor of native plant establishment. However, it may also provide optimum conditions for germination of exotic seed present in the soil. Herbicide removes preexisting plants at the site, which provides space and resources for the germination of a greater number and diversity of seedlings.

The increase in exotic seedlings can also be attributed to this decrease in plant cover. Because care was taken to avoid the patches of invasive species when the seed was harvested, the exotic seed must have been in the seed bank. Although the dominant species at the site, and presumably in the seed bank, was Boer lovegrass, Lehmann lovegrass apparently germinated more readily. The fact that a greater number of exotic grasses established in the plots that underwent herbicide application may be a cause of concern because any effort to establish native species will simultaneously increase the invasive species. Restoration efforts to increase native species diversity through herbicide, mowing and seeding will require follow-up of weed control.

The fact that numbers of previously existing plants did not differ between treatments suggests that the plots had low density initially. Plots with vegetation removal through use of herbicide did not differ from the plots with no removal of preexisting vegetation- in either native or exotic species. Hence, even a relatively small infestation of Boer lovegrass can have a large effect on the potential for establishing native species.

Mowing may have an additional effect. Fewer exotic seedlings established in the plots that were sprayed, seeded and mowed than those that were only mowed and seeded. In the process of mowing, the cut biomass is left on the ground, which has the effect of shading. This shading effect may prevent the establishment of exotic grass seedlings, which require light to germinate. By increasing the open canopy through herbicide application, the greatest number of exotic seedlings germinated, and by decreasing the open canopy by mowing, the fewest number of exotic seedlings established. Providing shade through mulch may decrease the prevalence of exotic seedling establishment, and hence may be an additional tool for increasing native diversity without the exotics.

Conclusion

The establishment of native species in stands of exotic grasses is effected by applied and existing factors. These studies indicate that more comprehensive studies are needed to

establish methodology for seeding into stands of exotic grasses. Future studies will involve the use of hay bales harboring native seed.

Table 3. Species Composition in *Mow + Herbicide + Seed* Treatment

Block	Frame	Species- seedlings	Species- mature plants
A	1	*Grasses*- ERLE[1],ERIN,BOGR,LEDU,ARTE,LYPH *Forbs*- Croton, Sida NM, Dychariste, Evolvulus, Chaetopappa, Portulaca suffrutescens, Falls witchgrass (Digitaria cognata)	None
A	2	*Grasses*- ERLE[1],BOCU,ERIN,ARTE,DICA,BOHI	None
B	1	*Grasses*- DICA,ARHA,ERIN,BOGR,LEDU *Forbs*- Dychariste, Sida, Cudweed, daisy	None
B	2	*Grasses*- ERCU[1],ERIN,ARTE,BOCU *Forbs*- Dychoriste,Daisy, Cercium (thistle)	None
C	1	*Grasses*- ERIN,BOCU,LEDU,ARTE,DICA	ERCU[1], Dychariste gnaphalium
C	2	*Grasses*- ERLE[1],ERIN,LEDU,DICA,BOCH *Forbs*- Sida, Dychoriste, Evolvulus, bundleflower	None
D	1	*Grasses*- DICA,LEDU,BOGR *Forbs*- Cudweed, bundle flower, Mtn. caliandra, ragweed,evolvulus, dychoriste	None
D	2	*Grasses*- DICA,ARTE,ERIN,BOGR,LYPH *Forbs*- Daisy,Cudweed,Desert marigold, Conyzia	None

[1]Exotic grasses consisted of ERLE (Lehmann lovegrass) and ERCU (Boer lovegrass)
Native grass species consisted of ERIN (Plains lovegrass), LEDU (Green sprangletop), ARTE (Purple threeawn), ARHA (Spidergrass), LYPH (Common wolftail), DICA (Arizona cottontop), HIBE (Curly mesquite), BOBA (Cane beardgrass), BOGR (Blue grama), BOCU (Sideoats grama), BOCH (Sprucetop grama), BOER (Black grama).

Table 4. Species Composition in *Mow + Seed* Treatment

Block	Frame	Species- seedlings	Species- mature plants
A	1	*Grasses*- ARTE *Forbs*- Sida, Dychariste	*Grasses*- ERCU[1],BOCU *Forbs*- Hierba de pasmo, convolvulus, sida, evolvulus, ragweed, chaetopappa, mimosa
A	2	*Grasses*- ERLE[1],BOGR,ATRE,ERIN *Forbs*- Ragweed, Evolvulus, Dychoriste	*Grasses*- ERLE[1],HIBE,BOCU,BOGR,ERIN,ARTE,DICA,BOHI
B	1	*Grasses*- BOGR	*Grasses*- ERCU[1],BOGR *Forbs*- Dychoriste, Ragweed
B	2	*Grasses*- BOCU,ERIN, *Forbs*- Dychoriste,Mtn. Caliandra	*Grasses*- ERCU[1],BOGR *Forbs*- Evolvulus,Prostrate sida,Upright sida
C	1	No data	No data
C	2	*Grasses*- BOGR,ATRE,DICA,LEDU *Forbs*- Dychoriste, Portulaca, Daisy, Evolvulus,Hybanthus	*Grasses*- BOGR *Forbs*- Sida, Evolvulus, bundle flower, flame flower
D	1	*Forbs*- Ragweed, Dychoriste	*Grasses*- ERCU[1],BOER *Forbs*- Evolvulus, Dychoriste
D	2	*Forbs*- Dalea, bundleflower, Dychoriste	*Grasses*- ERCU[1],BOBA,BOCU,BOCH,ERIN *Forbs*- Dychoriste, Bundle flower, Upright sida, Portulaca suffrutescens

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Table 5. Species Composition in *Seed Only* Treatment

Block	Frame	Species- seedlings	Species- mature plants
A	1	*Grasses*- ERIN,ARTE,BOGR,DICA	*Grasses*- ERCU[1],BOGR
A	2	*Grasses*- ERIN,ARTE,BOGR	*Grasses*- ERCU[1],BOCU,BOGR *Forbs*- Dychoriste, Chaetopappa
B	1	*Forbs* - Dychoriste	*Grasses*- ERCU[1],ERLE[1],ERIN,BOCU,BOGR *Forbs*- Dychoriste, Evolvulus, bundleflower
B	2	*Grasses*- ERLE[1],ARTE	*Grasses*- ERLE[1], Panic grass *Forbs*- Evolvulus, Prostrate sida, bundle flower, Dalea
C	1	*Grasses*- ERLE[1],BOGR,LEDU,ERIN *Forbs*- Portulaca, Dychariste, Calliandra hymulus	*Grasses*- ERCU[1],BOGR *Forbs*- Dychariste, Evolvulus, Poinsetta radiens
C	2	*Grasses*- BOCU,BOGR *Forbs*- Sida, Portulaca, Dychoriste	*Grasses*- BOGR,BOCU *Forbs*- Sida
D	1	*Grasses*- BOGR	*Grasses*- ERCU[1]
D	2	*Grasses*- LYPH *Forbs*- Dychoriste	*Grasses*- ERCU[1],BOBA *Forbs*- Evolvulus, Chaetopappa

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Table 6. Species Composition in *Control*

Block	Frame	Species- seedlings	Species- mature plants
A	1	*Grasses*- BOGR	*Grasses*- ERCU[1],BOCU,BOGR
A	2	None	*Grasses*- ERCU[1],BOGR *Forbs*- Day Flower, Bundle flower, chaetopappa
B	1	*Forbs*- Cudweed, prostrate sida	*Grasses*- ERCU[1],BOCU *Forbs*- Daisy, Evolvulus, bundleflower, Prostrate sida
B	2	*Grasses*- ERLE[1] *Forbs*- Bundle flower, Mtn. Calliandra	*Grasses*- ERCU[1],ERLE[1],ERIN *Forbs*- Evolvulus, prostrate sida
C	1	*Grasses*- ERLE[1],ERCU[1],HIBE *Forbs*-Dychariste, Bundleflower, Sida NM	*Grasses*- ERCU[1],BOCU,HIBE,BOCH *Forbs*- Portulaca, Bundleflower, Sida
C	2	*Grasses*- ERCU[1], Unk. grama species *Forbs*- Dychoriste, Sida NM	*Grasses*- ERCU[1],BOGR *Forbs*- Unknown forb
D	1	*Forbs*- Dychoriste	*Grasses*- ERCU[1],BOGR,HIBE,BOCH,LYPH *Forbs*- Chaetopappa, Red maids, Bundleflower
D	2	*Forbs*- Portulaca suffrutescens, Dychoriste, Mtn. Caliandra, falls witchgrass, hybanthus	*Grasses*- ERCU[1],BOGR,BOER *Forbs*- Ragweed, Evolvulus

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